Space Weather Technical Forecast

Issued on Sunday, 14 May 2023 at 01:11 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight Chance of G1, fading before midweek UTC. Chance of R1/R2 radio blackouts, decreasing slightly into new week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the last 24 hours, with X-ray activity recorded at GOES16 confined to occasional C-class flares. These peaked with a long-duration C9.0 at 13/0044UTC, originating from AR3296 on the northwestern limb, with the focus of smaller C-class flares then shifting east to the vicinity of AR3302 and especially AR3305. This event produced a mainly westward-heading Coronal Mass Ejection (CME), which was analysed as a deterministic miss, but with a small minority of MOSWOC Enlil members having a slight glance possible straddling the UTC days of 15 into 16 May.

An SDO data outage covered almost the entire period from 13/0130UTC, rendering sunspot analysis more difficult, and as a result observed sunspot trends are necessarily very general for the period. There are up to six regions visible in available GONG intensitygram imagery, with AR3296 presumed to remain in place on the very edge of the disc on the northwestern limb by inference from continuing C-class activity.

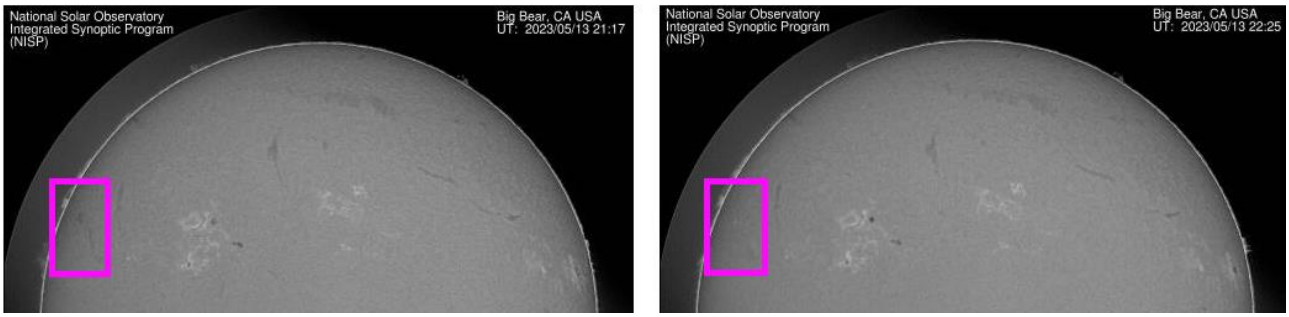

Figure 0: Northeastern limb possible filament lift-off. Any CME has yet to be determined, however Earth-based impacts are considered unlikely from such a (eastern) limb-ward location.

No new major CMEs were observed in the period. At 13/2100UTC, a disappearing filament was observed in Big Bear H-Alpha imagery from the northeastern quadrant. Any Earth-directed component is unlikely from this location, but with the caveat that confirming analysis has yet to be conducted. A similar such event was then seen from the southeast on the same imagery at 14/2300UTC, with analysis also yet to be conducted. The only other CME visible on coronagraphs a narrow west-heading feature that appears narrowly far sided to no effect at Earth.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was mainly suggestive of the last vestiges of the 09 May CME and then a nominal slow regime, however an unexpected IMF enhancement occurred later in the UTC day - possibly an SSBC. This may now be the start of a minor positive polarity fast wind as of 14/2130UTC, although this is not conclusive. As part of this, the IMF changed from a very smooth and level trend near 5nT to linearly approach

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a peak of 15nT at 20UTC, before returning to previous levels. The north-south component was consistently co-aligned with Earth's 15nT field with a peak of +6nT, with the notable exception of the UTC evening, which saw a sharp descent to a nadir of -14nT before recovering. The solar wind speed throughout this process remained unmoved from its descent through Slightly Elevated levels, as initial values of 500 eventually stabilised near 425km/s. The solar wind density was mostly within its typical background range, but peaked near 10ppcc in the early evening. The phi angle was mostly positive (away from the Sun), but became more changeable from 17UTC.

The net result of the above solar wind measures was mostly Quiet, but with a provisional peak of Active Kp4 since the possible SSBC in the 18-21UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, remained at Background level through the period.

High energy electron flux (greater than 2MeV), as measured at GOES16, ranged from Moderate to Normal Background levels, with a peak of 361pfu seen at 13/1615UTC. The 24-hour integrated fluence has been well below Active levels, with a near-level tendency. At 14/0001UTC, 6.8e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of returning to Moderate, with this risk greatest over the current UTC weekend while AR3296 remains on the disc, else tentatively falling a little into the new working week, with no major returning regions expected.

Solar Wind / Geomagnetic Activity: The preferred forecast is for Quiet conditions through this four-day period.

There are complicating factors: firstly in the form of up to three CMEs, namely the 11 May M2.1 southwest quadrant CME; the 12/0500UTC southwest filament CME; and the 13/0045UTC west limb CMEs that all have some form of glance in a minority of MOSWOC Enlil ensemble members on 14 through 16 May, however misses are all considered more likely to no effect.

In addition to the above, there is a tenuous and unnumbered positive polarity coronal hole near the solar equator in the western solar hemisphere, with MOSWOC Enlil suggesting a 450-500km/s fast wind is possible, although this is again not the preferred forecast. Should this occur it appears to be at least 24 hours away from STEREO A MAG evidence, and should not cause significant activity.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux now carries a daily Slight Chance of S1, decreasing slightly into the new working week as the main sunspot responsible for this risk crosses the limb and rotates away.

High energy (greater than 2MeV) electron flux is expected to persist at Normal Background to Moderate levels. The associated 24-hour fluence is forecast to persist below the Active threshold.

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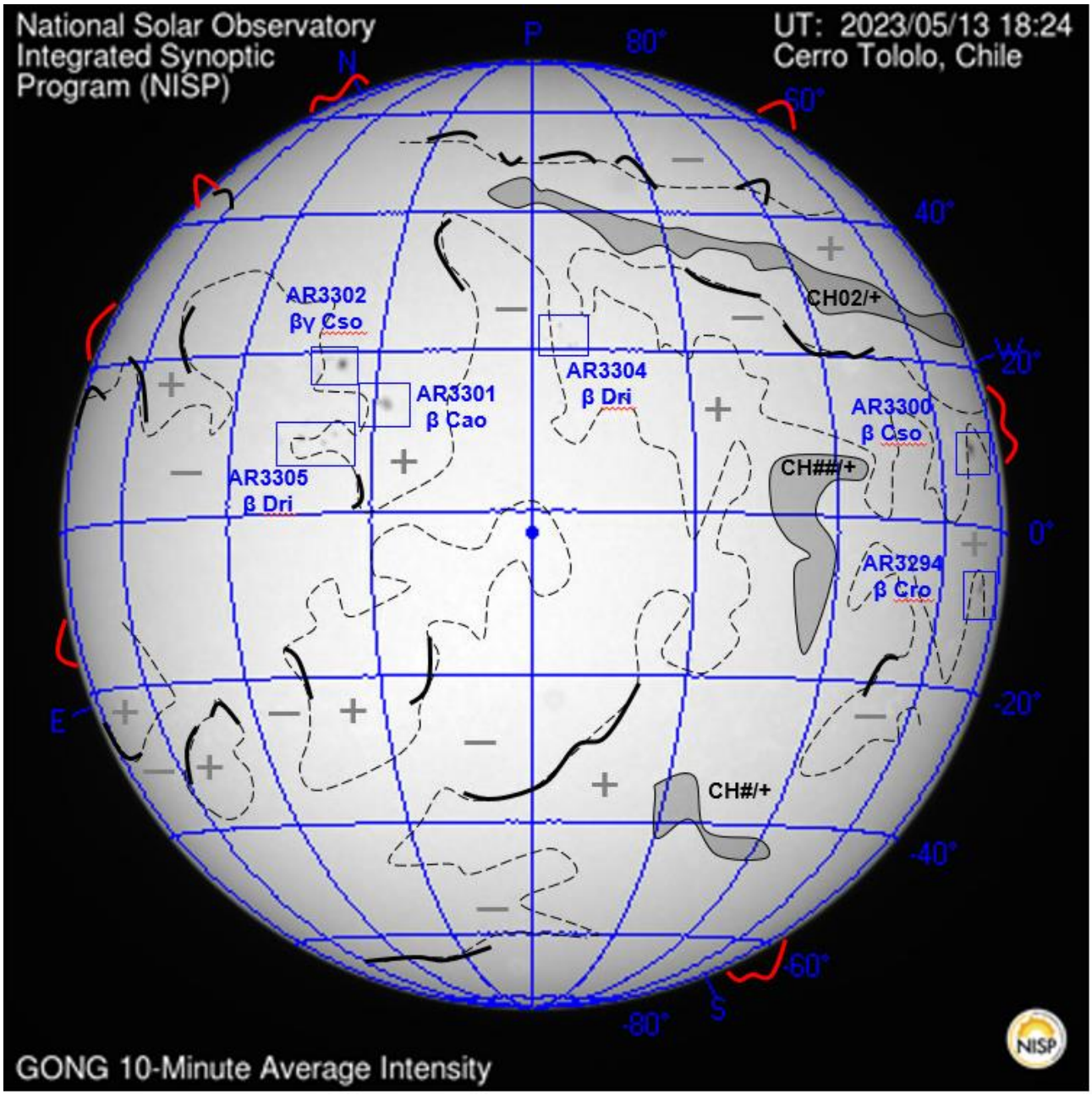
Figure 1. Solar Analysis Valid 14/1825UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic headline for this period is for mainly Quiet activity.

Having said the above, there are numerous possible complicating factors. Firstly, up to three CMEs feature as narrow glances in a minority of MOSWOC Enlil ensemble members. These are namely the 11 May M2.1 southwest quadrant CME; the 12/0500UTC southwest filament CME; and the 13/0045UTC west limb CME. These feature in succession from 14 through 16 May, however misses are all considered more likely to no effect at Earth, as shown in the main deterministic run.

In addition to the transients, there is a tenuous and unnumbered positive polarity coronal hole near the solar equator in the western solar hemisphere, with MOSWOC Enlil suggesting a 450-500km/s fast wind is possible, although this is again not the preferred forecast. Should this occur, it appears to be at least 24 hours away from STEREO A MAG evidence, and should not cause significant activity. The persistence forecast is expected to show little impact from high latitude coronal hole 02, whose influence is assumed to pass above the ecliptic plane throughout the period.

As of 14/2130UTC, a possible SSBC led to an eventual re-establishment of a positive phi solar wind – the solar wind speed is largely unchanged, but there is a small chance that this could represent a minor fast wind regime, with this to be seen in the coming hours. It is not expected to be impactful, regardless of the source.

All considered, a Quiet geomagnetic forecast is Expected. There is a daily Slight Chance of G1 from each or any of the 11, 12 and 13 May CMEs, and perhaps also the unnumbered coronal hole through to and including 16 May, with Quiet conditions then more assured in the absence of any new activity by day four, Wednesday 17 May.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	10	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Most likely nil. See main text for low confidence glancing impacts.

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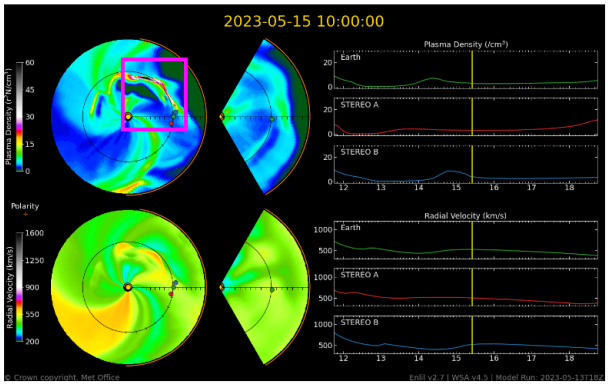
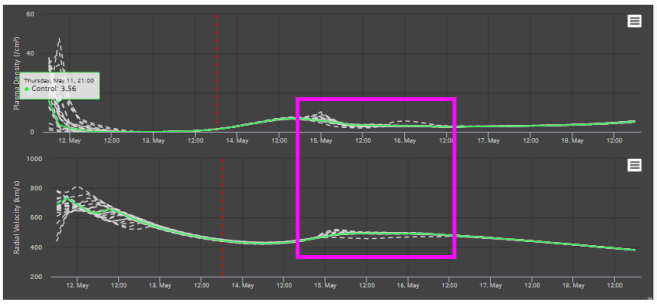
Figure 2: Latest MOSWOC Enlil run and ensemble, showing very minor glancing incidence in a minority of members between 14 to 16 May inclusive. The magnitude of any glacing blows has reduced in recent runs, however the unperturbed deterministic remains the favoured solution. The minor fast wind stream that these CMEs are overlaid on is considered possible but not impactful.





Radio Blackouts - X-Ray Flares:

There are six sunspot regions that remain visible on NSO GONG intensitygram imagery in the period, in the absence of the higher resolution SDO imagery. Discerning their Mt Wilson and Zurich classes is not possible to any degree of precision, and a persistence of their status as at 13/0130UTC is preferred, at least in the short-term and given the trends at that time (i.e. mostly slow decay). As stated, overall, the Sun seems to be entering a episodic lull in activity, with the Penticton 10.7cm flux falling from a midweek high of 180sfu on 09 May to reach 144sfu on 13 May.

There appears to be little expected in terms of returning Carringtons for sunspot regions in the period, however a northeastern limb CME to end the last working week may hint at a region here, although it is at least a day away from the front side judging by its apparent absence from the latest available STEREO A EUVI 195 imagery.

The outlook for X-ray activity is therefore tentatively a slight step-wise decrease as AR3296 departs early on day one, Sunday 14 May, however confidence in this assertion is very low given deficiencies in imagery, and a resurgence in activity could occur at any time.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	40	30	30	30
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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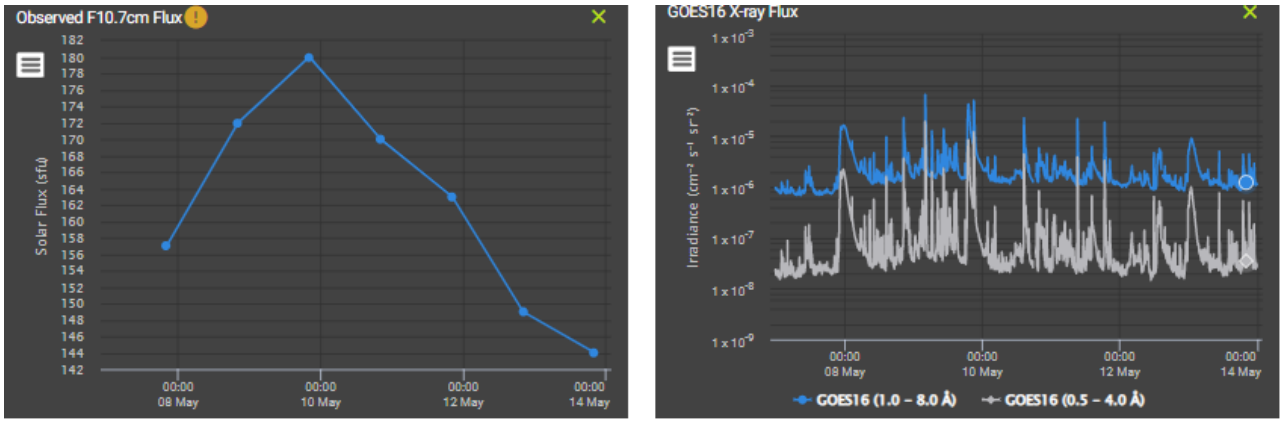
Figure 3: Penticton 10.7cm radio flux and GOES16 X-ray flux over the past week – the midweek high-point in activity appears to be entering a lull, with this likely to be further deepened by the imminent departure of AR3296.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at its resting Background through this 24-hour period. The long-period C9.0 from AR3296 did generate a proton enhancement at L1 at the very lowest energies, with 50keV protons showing a slight enhancement at ACE EPAM LEMS only.

The most likely source for generating S1 events (AR3296) is now occupying the most reliably-connecting sector of the Sun (with Earth), should a suitable flare and solar radiation storm arise. The probabilities of S1 events are therefore held slightly above the raw risk for the disc, especially given AR3296 is now difficult to fully analyse given imagery outages and limb foreshortening effects. The risk should very gradually ease into the new UTC working week as this spot group rotates from this potent position.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	20	15	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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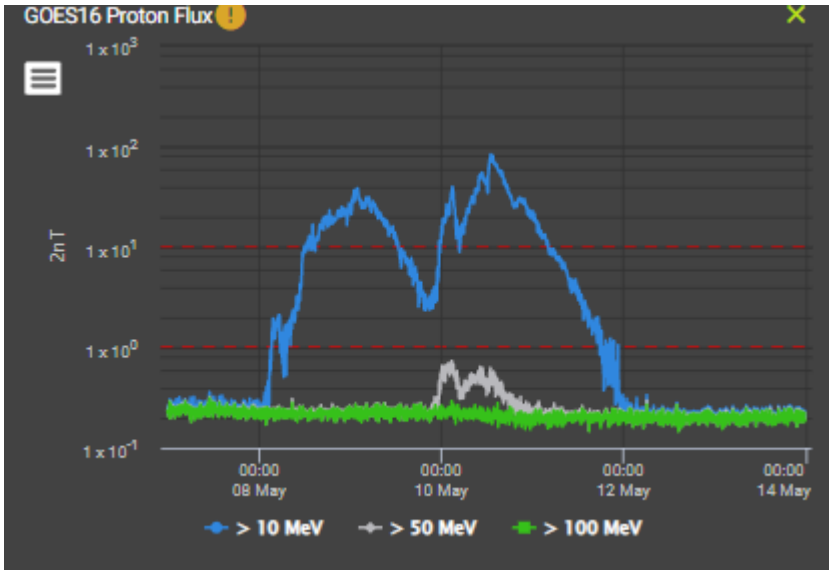
Figure 4: Past week in high energy proton flux, with S1-level enhancements as shown still considered possible with a gradually diminishing daily Slight Chance, falling as AR3296 rotates onto the far side.



High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) has ranged from Moderate to Normal Background levels over the past 24 hours, as in the previous UTC day, implying a steady state has been reached.

With very little on the disc likely to cause a significant solar wind speed enhancements (the tenuous unnumbered coronal hole included), electron flux and fluence ought to remain below Active throughout, with increasing uncertainty later in the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	5	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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